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NOTES ON THE GEOLOGY OF THE GOLD FIELD OF CRIPPLE CREEK, COLORADO.

BY H. L. M'CARN, DENVER, COLO.

THE granites surrounding the mineral district of Cripple Creek are of the ordinary types common to the Front Range. They vary from moderately fine to coarse grained in texture. Bedding structure is generally rather indistinct, but in places is strongly marked, and the rock may be more correctly styled gneiss. The quartz in these granites is either of a vitreous translucent or milky variety; the feldspar (orthoclase) usually pink. Biotite is the common mica, but other micas are met with, especially close to the mineral belt; one of these varieties being a black mica with splendent lustre, sub-translucent and dark green by transmitted light. It is strongly iron-bearing, very easily fusible to a black globule and is undoubtedly closely allied to, if not identical with, lepidomelaur.

In the granite ridge bounding the town of Cripple Creek on the west, are seen veins of amorphous, white or rose quartz, often six inches or more in thickness, apparently dispersed without relation to bedding structure, or order of any kind. Similar veins consisting wholly of pink feldspar occur in the same manner. Nests of large tabular prisms of a black mica (lepidomelaur) are also met with. Much of the granite here is of a very coarse texture, the various constituents being often an inch or more in diameter. These veins of quartz and feldspar, the nests of mica, as well as the very coarse textured granites, may all be attributed to a common cause, and have every appearance of having been formed contemporaneously with the consolidation of the containing granite. To the east of this ridge, in the town, as well as in other parts of the district, there occur "endogenous" veins of quartz, associated with parallel veins of feldspar, which are two or three feet in width and may be traced some distance in approximately straight courses. These veins are probably of secondary origin—concretionary veins—due to causes similar to those to which the various alteration belts of rock of the mineral area may be attributed. From the normal granites surrounding the district, towards the centre, occur innumerable phases of altered granitic rocks. Schists, aplites, felstones, conglomerates and breccias abound in numberless varieties, and transition rocks have been observed linking together rocks of very different appearance. Although this region is laid down on Hayden's maps as "eruptive," no true eruptives were seen *in the mineral belt proper*, with the exceptions of a black magnetic dyke in the town, and the rock composing what is known as "Bull Cliffs." These eruptives will be discussed further on. To give distinctive names to the various altered rocks of the district would be as difficult a task as attempting to name the shades from blue to green. Some sort of a classification of the most marked types should, however, be made. The nomenclature in use by the miners is confusing in the extreme and renders an attempted description of the country rock of a mine unintelligible. Granite, schist, porphyry, quartzite and trachyte are the miners' rocks. The term granite is applied to the binary granites as well as to the normal granites, if the rock is coarse-grained and the feldspar still pinkish, but if the feldspar is white, some call it "porphyry," while others speak of it as "quartzite," the choice of terms depending, probably, on their individual preference for the one or the other as a country rock for their claims. These micaless granitic rocks are from course to fine granular in texture—some even passing into a micro-crystalline aggregate. In color they range from white, through bluish-gray and gray, to yellow or brown. Some are pyritous, some mellose, in a fine grained magma, porphyritic crystals or blotches of white feldspar; while others have a leached-out appearance and are often colored yellowish or brownish by iron oxides. Curiously, this last-mentioned type is the one universally called "porphyry" by the miners. It composes the walls of many of the best mines (especially near the surface at depth passing into a grayish, often pyritous felstone) and is a favorite country rock. In the veins it often forms a veinstone, seamed with secondary quartz carrying gold. This so-called "porphyry" is sometimes beautifully zoned with concentric rings of brown or yellow, due to the oxidation outward of iron salts—the rusty bands giving the rock a riband appearance. The interior of such rocks is generally found to be a fine granular, gray material somewhat resembling sandstone, and often containing small grains of white iron pyrites. The micaless granites, where coarse in texture, might be termed "aplites," the fine-grained varieties "felstones." By prefixing descriptive adjectives, such terms as porphyritic gray felstone, pyritous felstone, yellow or brown felstone, etc., etc., would convey some idea of the character of the rock under discussion. There are two distinct mica schists in the camp. In one the mica is a black iron-bearing variety, the rock often appearing to be a disintegrated granite with schistose structure and very friable. This rock is considered an unfavorable country rock. The other schist is a tough, laminated, white rock, the mica being in large leaves of glistening, silvery-white muscovite (or a hydrous alteration variety of muscovite). This latter rock occurs in bands through the heart of the mineral area and in one or two instances was seen apparently bedded with beds of coarse granular, white "aplite" lying conformably upon its dipping surfaces. Some good mines are found in this rock, or rather on its contact with other rocks. The "Bull Cliffs" eruptive is locally called trachyte. The term is not, however, confined to this eruptive, but is given to many dark varieties of rock, of various structure, some of which bear a strong eruptive appearance in hand specimens. Some of these rocks are hard and compact, ring when struck with a hammer, and often contain small grains or prisms of hornblende. These rocks are usually in dark shades of gray and are occasionally exquisitely traced with imitative figures resembling trees, ferns, etc., due, doubtless, to a saturation of the rock with water, which, acting on

the hornblende or irons in the rock, decomposes these minerals. Capillary attraction brings the solution to the surface, where the mineral matter is deposited in the forms mentioned.

Careful examination, wherever exposures showed contacts with other rocks, failed to show any evidence of heat or local metamorphism of any kind. Transition rocks found in the immediate vicinity, as well as in other parts of the district, seem to furnish most of the links between these eruptive appearing rocks and well recognized metamorphic rocks. The absence of visible glassy enclosures, the mode of occurrence, and the fact that intermediate varieties occur, afford evidence that these rocks are simply alteration products of the granites. They might be termed "hornblendic felstones." Types of these rocks have been noticed as patches or masses included in the bedding of alteration granites, where they have the appearance of being due to some concretionary process, whereby they have become segregated into patches more basic than the balance of the formation. Belts of conglomerates and breccias occur in the district, and many good mines are found in such formations. The above mentioned altered granitic rocks comprise the most marked types, but the various varieties graduate one into another by innumerable transitions.

Evidence of bedding is often plainly discernible in these rocks, but stratigraphical study is very difficult owing to the "wash" or "slide" that covers the rocks, sometimes to a depth of sixty or eighty feet. Exposures are rarely to be seen except in the excavations made in prospecting and mining. Some of the belts of altered rock appear to be the upturned edges of regular bedded deposits, but in most cases they seem to be *zones of alteration*, and usually have a more or less northerly and southerly trend. Many of these belts are impregnated with iron pyrites (always to some degree auriferous) and constitute impregnated zones similar to what are termed "fahlbands." The gray pyritous felstones occur in this manner. As before stated, these rocks, especially where they have been leached of their auriferous pyrites and colored brown or yellow by the iron oxides resulting from the decomposition of the pyrites, are the rocks always spoken of in the camp as "porphyry." It is not surprising that the veins occurring in these rocks are so rich in gold, but it must not be understood that it is the only favorable country rock of the district. A number of excellent mines have solid granite walls, and others equally good occur in the various formations heretofore mentioned. The disintegration of the granites has resulted in giving the hills gentle rounded slopes, instead of the cliffs and bold escarpments such as make up the grand, precipitous scenery of Cheyenne Cañon and the other beautiful cañons around Pike's Peak. This disintegration is going on at the present time in the rocks at a little depth from the surface. In one tunnel on the northwest slope of Bull Mountain, at a depth of perhaps 200 feet, and 400 or 500 feet from the mouth, the micaless granite is found saturated with water. The formation is broken up similarly to what is termed "loose formation," met with near the surface in most mines. The rock is, some of it, so rotten as to fall to pieces in handling, though at rest it looks to be firm, with the feldspar porphyritically developed. Examination shows the feldspar to be kaolinized and soft and the rock very friable. Two or three veins have been cut by this tunnel, and in these veins kaolin seams and earthy oxide of manganese are forming, so that one can see *mineral veins in process of formation*. Gold is found in these seemingly unfinished veins, but where cut by the tunnel, they are understood to be "low grade." It may be well to say here that in this district, as in fact in most mining regions, the richest ore occurs in "shoots" or "courses," and a vein may be opened by shaft, or cut by a tunnel, in a comparatively barren part. Drifting on such a vein will often develop richer ore without, necessarily, any particular change in the outward appearance of the ore. In this event an "ore shoot" has been cut, which may extend longitudinally no great distance, but vertically, or downwards at various inclinations, it may extend to great depths. This characteristic of mineral veins has been the cause of many good mines being abandoned, on account of cutting through an "ore shoot" and "losing the ore."

The broken up condition of the rock in the tunnel above alluded to is probably a result of the disintegration going on, portions of the rock, for some reason, resisting the action of water, etc., better than the other parts, thus leaving angular or rounded fragments unaffected. These fragments become cemented together afterwards by mineral matter from solutions, and thus form conglomerates and breccias, such as are found in the belts heretofore alluded to, as well as in the mineral veins.

The veins of this district are, in most cases, unquestionably, true fissures, and "sheeting" of the country rock parallel to the main fissures is a characteristic of many of them. The fissures seem to diverge from several centres in directions between 45° each way from north and south, and but few veins occur nearer east and west than 45°. Where bedding structure can be discerned, the veins are found to cut the bedding either transversely, or at greater angles from the horizontal than the dip of the beds. The fissures evidently did not remain open to any great width, but sufficient cracks remained to permit the circulation of water through them. Mineral solutions have eaten out the faces of these cracks, and replaced the eroded material with silica and gold in the form of vesicular or crystalline auriferous quartz, together with iron and other vein minerals. Professor Emmons in a valuable paper ("Structural Relations of Ore Deposits," Trans. Am. Inst. of Min. Eng. Vol. XVI.) describes the parallel cracks which often accompany fissure veins as "minor fractures which form the adjacent country rock into parallel plates or sheets." There are many excellent examples of such sheeted fissure veins in the district, and it is largely these quartz-filled parallel cracks that yield the richest ore. In many mines the highest grade ore is the finely divided "screenings" resulting from the breaking up of their quartz seams by the blasts. The "clay partings" are also often rich in gold. Many veins have only one well defined wall—the other being so eaten into by mineral solutions as to alter it into ore. Sometimes both walls are thus altered. A kaolin selvage is often found on the defined wall, and in one mine in particular a "slickenside," composed of limonite, was seen taking the place of the clay selvage on a portion of the nearly vertical foot-wall. This "slickenside" was highly polished and striated, the groovings dipping at an angle of about 30° from the horizontal. Many walls are found hardened and grooved, where a regular "slickenside" was impossible, on account of the absence of the right sort of material necessary for its formation. These phenomena afford evidence of a movement of the walls and grinding action only met with in true fissures.

The veins are often mineralized to a considerable distance into the country rock, making it impossible to measure the width of the vein. In one mine belonging to the "Anaconda Group" the rock was quarried out to

a width or thirty feet or more. This mine is a good example of a great "sheeted" fissure—the sheets or plates varying from a few inches to two or three feet in thickness and separated from each other by nearly vertical quartz seams often rich in gold. There is also in this mine, a rich pay streak of vesicular quartz, wad and kaolin, which perhaps occupies what may be considered the "main fissure." The little quartz seams are the "minor fracture cracks" filled with secondary auriferous quartz, and the "sheets" or "plates" the country rock mineralized and changed into low grade ore. Seams and partings of kaolin (the talc or china-clay of the miners), as well as the selvages referred to, are common. Such seams are often followed downward, through the "slide" or "wash," which is generally the top beds decomposed *in situ*, and lead to good veins in the solid formation. Much of the ore is coated and impregnated with fine, white, auriferous iron-pyrites, associated with graphic tellurium (sylvanite), forming a rich and valuable ore. Some of this sylvanite ore is very beautiful as well as valuable—the surfaces being stained a rich blue verging on purple, by fluoric acid, and glistening with fine silvery white bars of sylvanite.

Few valuable minerals besides gold are found in the district. Silver is very seldom met with—the trifling amounts found in the ore being of no commercial importance. Copper is still rarer. Limonite is met with as a vein stone, and, in two or three instances, as a cap to the lodes. It seems to carry little gold, as a rule. Earthy oxide of manganese (wad) occurs in the veins with kaolin. A quartz peculiar to the district is the granular, sugary, massive quartz, often colored blue or purple by fluoric acid. This rock or ore contains a little orthoclase in grains, and is probably a felstone again altered by the mineral solutions circulating through the veins. In many mines it is rich in gold. Galena is very rare, but it is occasionally seen in the form of very small grains in vein stones. In one mine, fine anglesite crystals are found in geodes in a vein rock containing small grains of galena. They are small, tabular, white crystals of adamantine lustre, and result, doubtless, from the decomposition of the galena. Most of the vein matter is simply altered country rock—the kaolin resulting from the decomposition of the feldspar. The vein quartz is the silica which was separated from the silicate (orthoclase) and held in solution in the alkaline waters at the time of the kaolinization of the fieldspar. The iron and *gold* may have been derived from the iron-bearing micas (perhaps directly in some cases, or from pyrites which were themselves derived from the micas) and held in solution in the same alkaline waters that held the silica. These alkaline waters, circulating through the fissures, impregnated the walls and plates, and filled the cracks with auriferous quartz, together with the other minerals of the solutions. Surface water containing organic matter may have aided in precipitating the minerals. One of the most interesting and peculiar vein-stones here found is the variously colored jasper occurring in considerable quantities in the "Victor Mine" and to some extent in others. In the "Victor" the bright-colored cryptocrystalline jaspers are said to be very rich in gold, while the dark-brown earthy-looking varieties carry little or no value. This is very surprising, but a visitor will find very little of the first named variety "on the dump," while in the ore house he will find men carefully sorting and sacking ore for the smelters, and here he can see large quantities of jasper, some striped in shades of red, white and light brown, all of it going into the ore sacks. Sulphate of baryta (heavy spar) was noticed in one mine—associated with crystals of pyrite. Celestite, tourmaline and a few other interesting minerals occur, but are very rare. The mineral veins are, as a rule, singularly free from minerals valuable only to the mineralogist.

While the Cripple Creek mining district must be considered a typical granitic region, the two isolated eruptives heretofore mentioned are interesting to geologists and petrologists. The Black Dyke traversing the northwestern part of the district is at least thirty feet wide. It is questionable whether it reached the surface at any point, until erosion carried away the overlying granites and schists. Where partially excavated in the town, it lies in a belt of black, friable mica schist, but was not sufficiently uncovered to show the contact on either side. Further northwest on a spur of the granite ridge, which bounds the town on the west, this dyke is seen cutting through the granite, and some local metamorphism is apparent at the contact. Here it seems to have thrown out an arm; or rather, it looks as if, unable to force its way higher, the pressure from below was sufficient to force the granite beds upward a little, forming a space into which the molten or plastic matter found its way horizontally. Underlying this arm or sheet, between it and the granite, is a horizontal vein of white, massive, quartz, six inches in thickness close to the dyke, but gradually widening to two feet or more, forty feet away. The eruptive sheet becomes thinner as the quartz vein grows thicker, so that, taken together, they measure about the same throughout their course. The granite, which doubtless overlaid both, has been eroded away. Some prospector has opened the quartz vein by an open cut to the dyke, and tunneled some feet into the dyke itself. The quartz vein, where covered by the eruptive sheet, is strongly impregnated with copper pyrites, and coated blue and green by copper carbonates. Forty feet from the dyke the eruptive sheet comes to an end, and the quartz becomes white, losing all trace of copper. This is the only place in the district proper where evidence of copper was noticed, and it is clear, in this case, that the copper was derived directly from the eruptive rock. Macroscopically this dyke rock is a basic, compact, almost aphanitic, rock, very dark gray or almost black in color and showing minute, metallic grains disseminated throughout the mass. A polished surface, with the aid of a pocket lens, shows fine feathery flakes of a plagioclase feldspar ; the interstitial spaces being filled with a black or very dark green mineral (amphibole or pyroxene). This rock resists erosion well but weathers brown, slightly, on exposed surfaces. Its age is hypothethical, and microscopical study will be necessary to determine its petrological name.

The eruptive forming "Bull Cliffs" is of an entirely different character, and is known in the camp as "trachyte." It is a micro-crystalline rock containing glassy crystals (sanidine). A part of the deposit contains considerable hornblende in grains and prisms. The upper beds, however, contain little or no hornblende and are of a fine mottled greenish-gray and white appearance. This rock splits into slabs, often as thin as one-eighth of an inch with smooth surfaces. It resists erosion much better than the underlying hornblende-bearing rock. The latter disintegrates readily; exposed surfaces have a hackly appearance, and are spotted white with a decomposition product of the rock. The hackly weathered surfaces are often so friable as to crumble off in handling. Large blocks ring almost like steel when struck with the hammer. Hydrochloric acid eats out a considerable part of the rock (probably the nepheline). This eruptive does not seem to occur as a dyke, but rather as an isolated, massive eruption

of some kind. It is a variety of "phonolite." The writer does not believe that the two eruptives described have any bearing on the origin of the gold of this origin. Fire tests on the "phonolite" failed to reveal a trace of gold, and, as yet, no "pay mines" have been found in close proximity to the Black Dyke. The evidence all seems to point to the granite as the source from which the gold and other vein minerals were derived. Micas have been found by the work of Sandberger and others to contain nearly all the heavy metals (according to Phillips, gold, tellurium and mercury, "from want of the necessary appliances were not sought for" by Sandberger); and it would not be unreasonable to expect that future researches may reveal traces of gold in some of the micas of this region. If this prove to be the case, it would not be difficult to form some conception of the manner in which the different changes, which made up the evolution of great gold veins from granite beds, took place. This paper has attempted to convey some idea of the tremendous alteration and working-over by aqueous agencies, to which the rocks of this region have been subjected. If there is an analogy between this alteration and the occurrence of the gold, the *degree of alteration* would satisfactorily account for the great richness of the deposits, and afford much promise of permanence and value at great depths. The bands or zones of alteration were caused by the action of underground waters. There is no reason to believe that these waters were of a *very high temperature*, but that they were hotter than ordinary surface waters is undoubted. Subterranean waters are waters from the surface which have descended through cracks or by percolation through the porous rocks. As stated by Presturch, "the higher temperature of the waters at great depths would give rise to convection currents which establish a constant removal of the mineral matter in solution from deep-seated sources." The meeting of hot waters from below, charged with solid contents derived from the rocks, with surface waters, would reduce the temperature of the ascending waters; and the precipitating agents brought down by surface waters would bring about the deposition of the mineral matter in the interstitial spaces left by the removal of the matter originally therein. The process would thus be a constant interchange of matter—abstraction and replacement. In this way if minerals or rocks of a different character from those existing near the surface were met with and acted upon by these waters great changes could be produced; but, if the rocks were practically the same to great depths, as is likely the case in this region, the alteration produced would be simply changes in the texture of the rock, and in the proportions of the different constituents. These molecular changes would afford opportunities for the segregation and concentration of minerals, and would account for the concretionary veins of quartz and feldspar, heretofore described, as well as the zones or belts impregnated with auriferous pyrites. The micas of the granites would be acted upon; the iron and gold contained in the mica (if the mica held gold) changed into sulphates in solution, which were in turn reduced by the organic matter brought down by waters from the surface, to metallic sulphides (or the iron to a sulphide holding the gold in a finely divided metallic state), and deposited in the pores of rock already rendered porous as described above.

Accounting for the derivation of the sulphur necessary for the formation of sulphates is the one link missing in the chain of reasoning which makes up the theory of "lateral secretion." The votaries of the "ascension" and "sublimation" hypotheses hold that the sulphur must come from deep-seated sources, but they do not satisfactorily explain why it should be present at depth and not in the rocks a few thousand feet above. Neither do they tell us whence comes the sulphur in the great sulphide lead, zinc and copper ores of the upper Mississippi lead region. There the ore occurs in chamber deposits or flats in unaltered Silurian limestones; no eruptives of any kind are met with; and, so far as known, no fissures or other connections have existed, or do exist between these beds and the rocks underlying them at depth.

The atmosphere seems to have been, so far as the writer knows, not considered as a possible source from which the sulphur required for these reactions may have been derived. The carbon necessary for the formation of coal was derived from the atmosphere, and most geologists hold that the air must have contained a larger amount of carbonic acid at the beginning of the Carboniferous period than at the present time. Much sulphur is often present in coal. Is it unreasonable to conjecture that, during those early periods, the air contained gases which are no longer present, or only present in infinitessimal quantities? Great difficulty has always attended analyses of air, but the examination of rain water has thrown much light on the impurities contained in the atmosphere. Geikie says: "Nitric acid sometimes occurs in marked proportions—sulphuric acid likewise occurs, especially in the rain of towns and manufacturing districts. Sulphates of the alkalies and alkaline earths have been detected in rain." He attributes the disintegration of mortar in walls to the action of nitric and sulphuric acids of the air and says: "The mortar of walls may often be observed to be slowly swelling out and dropping off, owing to the conversion of the lime into sulphate." The Colorado Front Range is believed by geologists to have been raised above the sea, as a long, narrow, northerly and southerly island, at about the close of the Archean era; but not upheaved, into a great mountain range, until the close of the Mesozoic. There was thus ample time for the slowest kinds of chemical and molecular changes to take place in. Atmospheric erosion, during these countless centuries, must have carried away several thousand feet of the top beds. To make up for this waste, it is probable that the land was at times upraised to some extent. These sporadic upliftings would likely be accompanied by more or less disturbance of the strata; fissures would be produced, in the areas of greatest disturbance, which would form channels for the circulation of waters; and thus aid in the alteration of the country rock into the bands or zones heretofore described. It was during this period that the sulphur was probably introduced. Whether it was derived from the air and brought down by surface waters, or from the seas bordering this long island, through infiltration, or introduced from below in some manner, is as yet an unsolved problem. In the formation of these belts of alteration and auriferous pyrites "fahlbands" was the first stage in the genesis of these gold deposits; and "lateral secretion," aided by "ascension," which is a necessary adjunct to the *circulation* of underground waters, seems to account for the first stage, as well as for the more recent one of concentration into veins rich enough to work. At the close of Mesozoic time this long, narrow island, which had, for untold ages, existed as land, was thrown up into a mountain range. It was during the folding and contortion of these rocks, attending their upheaval, that the fissures, since filled with auriferous quartz, were probably formed. Enormous lateral pressure caused these great peaks and anticlinal ridges. A torsional

force acting in conjunction with this lateral pressure, would, as shown by Daubreé, cause fractures to occur on the sides of the folds, in the direction of the axis of elevation, or nearly so. These combined forces would, also, according to Daubreé and Emmons, cause the fractures to occur in more or less parallel groups, and would account for the minor fractures or sheeting structure so characteristic of this district. Most of the metalliferous fissures in the district are thus found on the sides of the anticlinal ridges, more or less parallel to their strike, and cutting the bedding vertically or at a much greater angle than the dip of the beds. When such fissures cut belts of pyritous felstone, it seems to be the invariable rule, that some portions, at least, of their course will be found rich in gold.

Waters containing carbonic acid and other solvents acting on the pyrites and orthoclase would decompose them and carry the iron, gold and silica in solution through the fissures. The iron and silica were precipitated as limonite and vein quartz, but the gold, for some reason, was not evenly deposited with the other minerals, but was segregated into "shoots" or "courses" through the veins, the portions of the veins lying between these "ore shoots" being "low grade" or comparatively barren. It is possible that these "ore shoots" owe their richness to their position in the old channels through which surface waters, containing organic matter, or other precipitants, flowed with greatest freedom.

The brown and yellow felstones, commonly called "porphyry" in the camp, are, as before stated, the pyritous felstones leached of their auriferous pyrites, in the manner described, and colored as they are by iron oxides. Much of the gold in the veins may have been derived by a more direct process from the micas, and did not undergo the intermediate stage of deposition with pyrites in zones of impregnation.

No sign of glacial action is apparent in the district, and no large streams are found in the close vicinity of the mines. The valleys or gulches are synclinal troughs rather than valleys of erosion. The products of surface or atmospheric erosion, *since the formation of the mineral veins*, remain for the most part *in situ*—the lack of transporting agencies, such as glaciers or flooded streams, accounts for the thickness of the "wash" and the comparative absence of alluvial gold in the streams draining the district. Placers occur as often on the *tops of the hills* as in the valleys. Some of the decomposed material from the very summits of the hills has proved so rich in gold as to well pay for transporting in wagons to the stamp mills.

If water for hydralicing was available most of the "wash" would yield rich returns.

No attempt has been made in this paper to describe the many really great mines of the district. The writer has simply endeavored to show the connection or analogy between the alteration of granitic rocks and the occurrence of the mineral in veins. If the cause of the concentration of mineral matter into veins is "lateral secretion," it is evident that the greater the chemical and molecular alteration the country rock has undergone, the greater the richness of the veins will be. If this hypothesis is the true explanation for the origin of the gold, the magnitude of the country rock alteration will easily account for the great richness of the mines so far discovered as well as insure their permanence and future value.

In conclusion the writer desires to say that the area under discussion in these notes includes only the mineral belt in which the present pay mines are located. It embraces about fifteen square miles, and does not include the mountains to the north and west, such as Rhylorite Peak and Mt. Pisgah, which, judging from their appearance at a distance, and the testimony of others, are probably of eruptive origin.

THE SYNTHETICAL POWERS OF MICRO-ORGANISMS—I.

BY O. LOEW, UNIVERSITY OF TOKIO, JAPAN.

AMONG all living organisms the micro organisms, micrococci as well as bacteria, bacilli and spirilli, are especially remarkable by their intensity of chemical activity. Oxydations and decompositions, reductions and synthetical processes are executed on an extensive scale. Numerous organic combinations are easily split up, and under atomic migrations substances of a more solid structure are formed, the products of fermentative actions. And amid this destructive activity, while the fight against easily changeable compounds is raging, there is built up in the interior of the cells the most labile of all combinations, the active albumen, being organized to living protoplasm. And this is done, under favorable conditions, with such rapidity that one cell can yield by growth and continual fission in twenty-four hours more than one trillion of new cells! What an energetic manufacture of living protoplasm, of living cells!

If we consider the destructive and synthetical operations, we must arrive at the conclusion that the former are necessary for carrying on the latter; the former yield not only the forces necessary for the synthetical work, but also the suitable atomic groups. It is certainly a highly interesting question of physiological chemistry to study the relations of the two different directions, and to elucidate which the groups are that serve for the synthetical work. In order to see our way clear we must at first consider the chemical structure of the combinations that can serve as nutrients, we must investigate the causes that bring about the transformation of potential into actual energy, and we must recognize, above all, that the proteids of the living protoplasm are chemically distinct, are different from those of the dead; we must acknowledge that when the labile character of the former changes by atomic migration to a stable one the death of the cells has come.

Nutritive and poisonous qualities are relative conceptions, poisons may become nutrients for bacteria when highly diluted, as phenol or acetic ether, and nutrients may become unfit for nutrition if the concentration reaches certain limits. Small chemical changes may convert a nutritive substance into a poison, and again the poison into an indifferent substance; thus the methan is indifferent, the methylic alcohol a nutrient, the methylic aldehyd a poison and the combination of the latter with bisulfite of sodium again indifferent, and even for a certain kind of bacterium a nutrient.

$$\underbrace{CH_4}_{\text{Methan}} \qquad \underbrace{CH_3\,OH}_{\text{Methyl alcohol}} \qquad \underbrace{CH_2\,O}_{\text{Methylic aldehyde}} \qquad \underbrace{\begin{matrix}CH_2\,OH—\\ SO_3\,Na\end{matrix}}_{\text{Methyl sulfonate of sodium.}}$$

Also the quantity of the produced fungoid matter depends a great deal upon the chemical constitution of the nutrient. Thus I have observed with cultures of mould fungi that tannin or tartaric acid yields only 10/12 per cent of their weight, acetic or succinic acids, however, 14/20 per cent, when nitrogen is present in form of ammonia salts. The more oxygen atoms are contained in a compound the less, naturally, will be the relative production of fungoid substance, but it makes a difference as to whether the oxygen atoms are present in form of carboxyl groups or in form of "alcoholic" hydroxyl groups. The easier a substance is decomposed, the more readily it will be used, and the quicker the development of cells will take place.